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Empirical Research on China's SMEs Technology Innovation Engineering Strategy

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Abstract

In order to reveal the economic effect and management effect in small and medium enterprises (SMEs), the theoretic model of technological innovation engineering is given in the paper. By model design, pre-test and pilot test, reliability test and validity test, factor analysis can effectively reveal the correlation among innovation planning, innovation implementation, innovation platform and innovation performance. For illustration, 245 questionnaires return from 11 provinces and autonomous regions, and the returns ratio is 70%, which satisfy the requirement that the questionnaire returns-ratio is not lower than 20% in the data investigation. The empirical results show that model fitting work well, and have high convergence validity. The research conclusions provide a realistic theory reference for SMEs-related technology innovation engineering in China.

Keywords: Small and medium enterprises (SMEs); technological innovation engineering; factor analysis

1. Introduction

SMEs are an important force for economic development at home and abroad. In the last century, the developed countries experienced a number of the tide of enterprise merger & purchase so that some large enterprises and multinational groups indeed appeared due to a big leap in the social productive forces. However, contrary to traditional economists' anticipation, the number of SMEs increased rather than decreased, and the contribution to economic development was increasingly significant. In Italy, Japan and France, the number of SMEs accounted for 99% of the total number of enterprises. In the United States there were more than 2000 million SMEs, accounting for 98% of total number of enterprises although America was famous for its large enterprises. In Germany, SMEs-related exports value accounted for over 60% of the country [1].

In China, the SMEs accounted for 99.3% of total number of enterprises according to statistics in 2006. In the tertiary industry with the low organic composition, SMEs had an absolute advantage in terms of the number, employment or contribution to national economies. For example, Shanghai was China's most developed industrial city. In Shanghai SMEs the numbers accounted for 98.7% of total number of enterprises, output value accounted for 30% of total output value, and the proportion of employment accounted for 71%. In China, the number of SMEs

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accounted for more than 90% of enterprises. More than 70% of local employment, more than 60% of industrial output and 40% of profits and taxes were due to SMEs [2].

The concept of technological innovation has been given for 70 years, but academic community has not formed a rigorous and unified definition [3]. From the perspective of scientific management, the definition of innovation generally comes from the United States Library of Congress: technological innovation is a complete process for new product or process for market application. It includes a series of activities such as new ideas generation, the commercial production and proliferation. The definition clearly shows that the technological innovation is the process of technology and economic integration, which emphasize that the ultimate goal of technological innovation is the commercial application of technologies and market success of new products.

Professor Fu Jiaji in Tsinghua University held that technical innovation was the potential profit opportunities for entrepreneurs to seize the market so as to make commercial interests, conduct re-organization of production conditions and factors, establish a production and operation system with stronger performance, more efficiency, which can introduce new products and new production (process) methods, open up new markets, obtain new supply sources of raw materials or semi-finished products, or create new organization activities including a series of integrated activities process such as science and technology, organizations, business and finance [4].

2. Model design

Technological innovation of SMEs has the following characteristics. From innovative technology form and content, the high-tech SMEs are based on product innovation, and SMEs are good at process innovation. From the innovative internal mechanism point of view, SMEs are suitable for technical innovation step by step. From the perspective of sources and means of technology innovation, SMEs focus on the domestic technology transfer innovation. From the organizational structure and activity method of innovation, cooperation innovation is the best choice for SMEs. From the novelty degree of innovation, SMEs-related technological innovation belongs to imitation innovation.

Compared with large enterprises, SMEs have numerous advantages. First, SMEs are so small and low level that they are able to make a highly efficient business decisions. Second, research and development (R&D) staffs as well as production and marketing staffs can contact closely so that they can better communicate and cooperate. Third, SMEs have high business conversion adaptability, the rapid technology absorption as well as innovative spirit. Fourth, with the low creation cost, high-quality and the potential of exclusive products, the majority of SMEs have professional features [5]. However, SMEs are inferior to large enterprises in respect of technical reserves, R&D capabilities, financing capability as well as risk tolerance.

In some traditional industries, SMEs-related technology innovation engineering promotes technological progress of these industries to conduct the revitalization and development of these industries. In some new industry, SMEs-related innovation activities are so active that they greatly promote the development and maturity of these industries. American scholars Arcos held that innovation activities of large enterprises prevail over in such industries as pharmaceutical and semiconductor, SMEs prevail over in such industries as computers and process control equipment, and SMEs particularly prevail over in such new industries as computer.

Based on the above analysis, the strategy model of SMEs-related technological innovation engineering in China is divided into four elements including innovation planning, innovation implementation, innovative platforms and innovation performance, which fully reflect the strategic structure of SMEs-related technological innovation engineering. Innovation planning refers to the overall design of SMEs-related technology innovation strategy. Innovation implementation refers to innovation behavior of a variety of business functions in SMEs. Innovation platform refers to the environment created by enterprises for technological innovation strategy. Innovation performance refers to SMEs-related technological innovation results. Each innovative element can be decomposed into a number of innovation indicators, which construct SMEs-related technological innovation model with a set of reasonable internal structure configuration shown in table 1.

Table 1. The strategy model of SMEs-related technological innovation

Elements name	Index name	Index significance
Innovation planning ξ1	Goal clarity X1	With clear objectives, enterprises play close attention to technological innovation.
	Innovation design X2	There is scientific and reasonable innovation design in enterprises.
	Innovation guide X3	Corporate leadership give the effective guidance to technological innovation activities.
Innovation implementation ξ2	Management innovation X4	Enterprises can effectively implement inner management innovation.
	Market innovation X5	Enterprises can effectively implement market innovation such as product marketing.
	R&D innovation X6	Enterprises can effectively implement technological activities innovation such as technology development.
	Innovative incentive mechanism X7	Enterprises develop the effective incentive mechanism to improve innovation efficiency.
Innovation platform ξ3	Human capital accumulation X8	Enterprises strengthen human capital accumulation to improve overall innovation capability
	Innovation cultural development X9	Enterprises strengthen technological innovation-oriented cultural development.
Innovation performance ξ4	Market performance X10	Technological innovation obviously improves market operational ability in enterprises.
	Production performance X11	Technological innovation obviously improve production operational ability in enterprises
	Management performance X12	Technological innovation obviously improves management standards in enterprises.

3. Model checking

3.1 Pre-test and pilot test

SMEs questionnaire design was based on the above analysis of technology innovation system, and then three experts in the field of technological innovation conduct questionnaire pre-test. The professional evaluation was related to the test content, questionnaire format, question clarity, content and terms in order to continue to be modified.

The pilot test was made towards the questionnaire after the pre-test. The object was related to 21 EMBA students of Nanjing University. After authors conducted an initial reliability analysis on these 21 questionnaire, Cronbach's α

values was used to test the reliability of the questionnaire. The results showed that the Cronbach's α value of variable distribution was between 0.7001 and 0.7522. According to Hau Kit-Tai's proposal, as long as Cronbach's α values was greater than 0.7, its reliability can be accepted. Therefore, there was the sufficient reliability in the questionnaire.

After pre-testing and pilot testing, 12 items were retained to test four elements SMEs-related technological innovation system in China.

3.2 Data collection

In the method of convenience sampling, the paper randomly selected a sample of 350 companies from the Beijing Tiansheng consulting firm's database. Samples distributed in 11 provinces such as Beijing, Tianjin, Shanghai, Chongqing, Henan, Anhui, Jiangsu, Zhejiang, Shanxi and Guangxi autonomous regions and so on, which represented the overall business situation of technological innovation in China's enterprises. There were electronic questionnaire, mailed questionnaires, telephone interviews, interviews, etc. Respondents were corporate CEO, CIO, CKO and other high-level persons. In the survey 245 valid sample data were returned, and the effective rate was 70%, which satisfied the requirement that the questionnaire returns-ratio was not lower than 20% in the data investigation.

3.3 Single-dimension scale test

The research results indicated that KMO values were between 0.723 and 0.823, and there were a lot of correlation in coefficient matrix (α =. 000). So samples were suitable for factor analysis. In the paper the factor extraction method was principal component analysis, the rotation method was varimax method, and the interception point of load factor was 0.5.

105 sample data were randomly selected to conduct exploratory factor analysis. Being rotated through 5 iterations, the results of exploratory factor analysis were shown in table 2.

Table 2 Exploratory factor analysis table

Secondary index	Factor 1	Factor 2	Factor 3	Factor 4
Goal clarity X1	.760	.271	3.56E-2	.310
Innovation design X2	.727	7.60E-02	.175	.221
Innovation guide X3	.684	.187	.453	.354
Management innovation X4	.352	.509	5.23E-3	5.08E-2
Market innovation X5	.451	.575	.234	.316
R&D innovation X6	3.31E-3	.801	.169	.187
Innovative incentive mechanism X7	.352	.210	.762	.196

Human capital accumulation X8	2.955E-03	.209	.711	2.12E-2
Innovation cultural development X9	.310	.271	.689	.421
Market performance X10	.289	4.44E-3	.310	.588
Production performance X11	.276	.198	.262	.821
Management performance X12	.333	2.121E-3	.103	.700
Cronbach's α	.7223	.7138	.8054	.7596
Cumulative variance (%)	19.980	38.908	62.256	81.123

The research results showed that the validity of the sample structure was strong, and the corresponding factor loadings of each indicator were greater than 0.5.

4. Reliability test and validity test

Reliability analysis is to verify the reliability of each observed indicators. Reliability aims to measure the consistency level to reflect the results of repeated measurements under the same conditions of the approximation. Table 2 showed that the minimum value of factors-related Cronbach's α was 0.7138, and the samples' validity was better [6].

Confirmatory factor analysis should pay attention to two conditions: the ratio of sample size and the index should be greater than 5:1; if the difference of the sample set used for confirmatory factor analysis and exploratory factor analysis was larger, the final results of factor analysis was better [6].

Both SPSS11.5 and LISREL8.7 were used to make confirmatory factor analysis, and factor load parameter list was shown in table 3.

Table 3. Factor load parameter list

Factor name	X1	X2	X3	X4	X5	X6
Factor load	.34	.70	.22	.21	.71	.21
SE	.07	.11	.06	.11	.11	.07
t	3.8	6.4	3.5	1.8	6.7	3.0
Factor name	X7	X8	X9	X10	X11	X12

Factor load	.26	.25	.64	.78	.22	.13
SE	.09	.08	.10	.12	.07	.08
t	2.9	3.1	6.4	6.5	3.1	1.6

Factor covariance matrix was shown in table 4.

Table 4. Factor covariance matrix

	Innovation planning	Innovation implementation	Innovation platform	Innovation performance
Innovation planning	1.0			
Innovation implementation	0.65	1.0		
Innovation platform	0.21	0.71	1.0	
Innovation performance	0.23	0.32	0.23	1.0

Model fit index was shown in table 5.

Table 5. Fit index list

Fit index	df	CHI-Square	RMSEA	NNFI	CFI
Present value index	36	50	0.066	0.933	0.929
Optimum value tendency	—	Small is better	<0.08	>0.9	>0.9

5. Conclusion

The fit index shows that model fit worked well [7]. Therefore, SMEs-related technology innovation engineering model in China has a high application value, which can fully reflect the realities of technological innovation engineering.

Based on the factor covariance matrix [8], there existed a strong correlation between innovation planning elements and innovation implementation elements. Therefore, in the implementation process of SMEs-related technology innovation strategy, the strategic planning for scientific technological innovation can improve the implementation efficiency of technological innovation. Meanwhile, there is a strong correlation between the innovation platform elements and innovative implementation elements. Therefore, a reasonable construction of the innovation platform can effectively improve the implementation efficiency of technological innovation.

The factor load parameter list shows that factor load value of both index X4 and X12 lacks significance. Therefore, during the strategy implementation of SMEs-related technology innovation in China, there is no

emphasis on incentives to management innovation engineering, so that the significant management innovation engineering performance doesn't appear. It reflects one-sided understanding of technological innovation engineering: the technological innovation only belongs to technology field, which is even equivalent to the technological invention engineering. The error idea has seriously hampered the improvement of China's technological innovation capability and the technological innovation efficiency. In fact, SMEs-related technological innovation should give priority to management mechanism innovation and marketing mechanism innovation so as to improve the overall efficiency of technological innovation engineering in China as soon as possible at present.

References

1.Lin Chao, Xiong Quan. The discussion on the role of middle managers in technology innovation of enterprises. Science and technology management research. 1(2004)141-143.

2.Tongjian Zhang, Sheng Kong, Xun Li, The strategic model of technological innovation of small and medium enterprises in China. Technoeconomics & Management Research. 6(2009) 28-30.

3.Jian Deng, Tongjian Zhang, Research on evaluation system of Chinese tourism enterprise. Technoeconomics & Management Research. 1(2010):6-8,19.

4.Jianqi Mao, evolution and complexity of technological innovation. Scientific research. 2(2007)168-172.

5.Shiqiu Hu, Huamin Song, Dynamic analysis of enterprise technical innovation system. Management.1(2005) 14-17.

6.Prahalad,C.K. and Hamel,G, (1990)The core competence of the corporation. Harvard Business review.

7.Ronald C. Beckett, A characterization of corporate memory as a knowledge system. Journal of Knowledge Management. 4(2000)311-319.

8.Aghion,P & P.Howitt, A model of growth through creative destruction. Econometric. 60(1992)323-351.